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SILVICAL *Characteristics* OF...

NORTHERN WHITE-CEDAR

(*Thuja occidentalis*)

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THE SILVICAL REPORTS

During 1907 and the following several years the U. S. Forest Service issued a series of silvical leaflets which covered the broad characteristics of a considerable number of major timber species. Since then much new knowledge has accumulated--some of it published in a variety of sources. There is also a considerable store of unpublished silvical information in the files of the forest experiment stations, the forest schools, and some other agencies. To compile this information systematically and make it available to foresters generally, the Lake States Forest Experiment Station has prepared reports on 15 individual species. Similar reports are being prepared by the other Federal forest experiment stations. When completed, these individual species reports will provide the basis for a comprehensive manual of silvics for the important trees of the United States, to be published by the U. S. Forest Service.

This report is the last of the series prepared by the Lake States Station. A preliminary draft was reviewed by several members of our own Station staff and by a number of well qualified staff members of other forest experiment stations, colleges, and universities; Federal, State, and Provincial forestry organizations; and forest industry. Their comments helped the author to make this report more complete, more accurate, and more up to date. Especially helpful reviews were submitted by: Professor R. C. Hosie, Faculty of Forestry, University of Toronto; Professors Fay Hyland and R. Ashman, University of Maine; Professor I. C. M. Place, formerly of the Department of Forestry and Wildlife Management, University of Wisconsin, now with the Petawawa Forest Experiment Station, Ontario; Philip Thomas and Donald Prielipp, Kimberly-Clark Corporation of Michigan; A. C. Hart, J. D. Curtis, and Tom Nelson of the Northeastern, Intermountain, and Southeastern Forest Experiment Stations respectively; R. F. Watt of the Lake States Station's St. Paul Office; and staff members of the Station's field units.

Every effort has been made to ensure the accuracy and completeness of the information concerning the silvical characteristics of each species consistent with a brief treatment of the subject. We shall appreciate it, however, if any errors or omissions of important information are brought to our attention.

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Cover: Mature northern white-cedar on the Upper Peninsula Experimental Forest, Dukes, Mich. Drawing represents leaves and cones.

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SILVICAL CHARACTERISTICS OF NORTHERN WHITE-CEDAR

(Thuja occidentalis L.)

by

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Northern white-cedar, a medium-sized tree, is the eastern form of Thuja and the smaller of the two American species of the genus. Locally the tree is often called eastern arborvitae, arborvitae, swamp-cedar, eastern white-cedar, or white-cedar (17, 20, 21, 38).[2/]

DISTRIBUTION

The botanical range extends westward from Anticosti Island in the Gulf of St. Lawrence to the southern portion of James Bay and through central Ontario to southeastern Manitoba in Canada; the southern boundary runs through central Minnesota and Wisconsin, along a narrow fringe around the southern tip of Lake Michigan and through southern Michigan, southern New York, and central Vermont and New Hampshire. It is also found locally to the north of the main range in northwestern Ontario and west central Manitoba, and to the south of the main range in Minnesota, Wisconsin, and Illinois, southern Ohio, the Appalachian Mountains of western Pennsylvania, eastern West Virginia, western Virginia, western North Carolina, eastern Tennessee, and Massachusetts (fig. 1) (20, 21).

Most of the remaining commercially important stands of northern white-cedar occur in northern Michigan, Wisconsin, and Minnesota; southern Ontario and Quebec, and in Maine and New Brunswick.[3/] The largest sawtimber stands were originally located in the Lake States. The largest present volume is in Ontario (7).

1/ Maintained by the Forest Service, U. S. Department of Agriculture, at St. Paul 1, Minn., in cooperation with the University of Minnesota.

2/ Numbers in parentheses refer to literature cited, page 14.

3/ Commercial range is defined as that portion of the botanical range within which the species grows to commercial size and is a major or important species in the type.

NORTHERN WHITE-CEDAR (Thuja occidentalis)

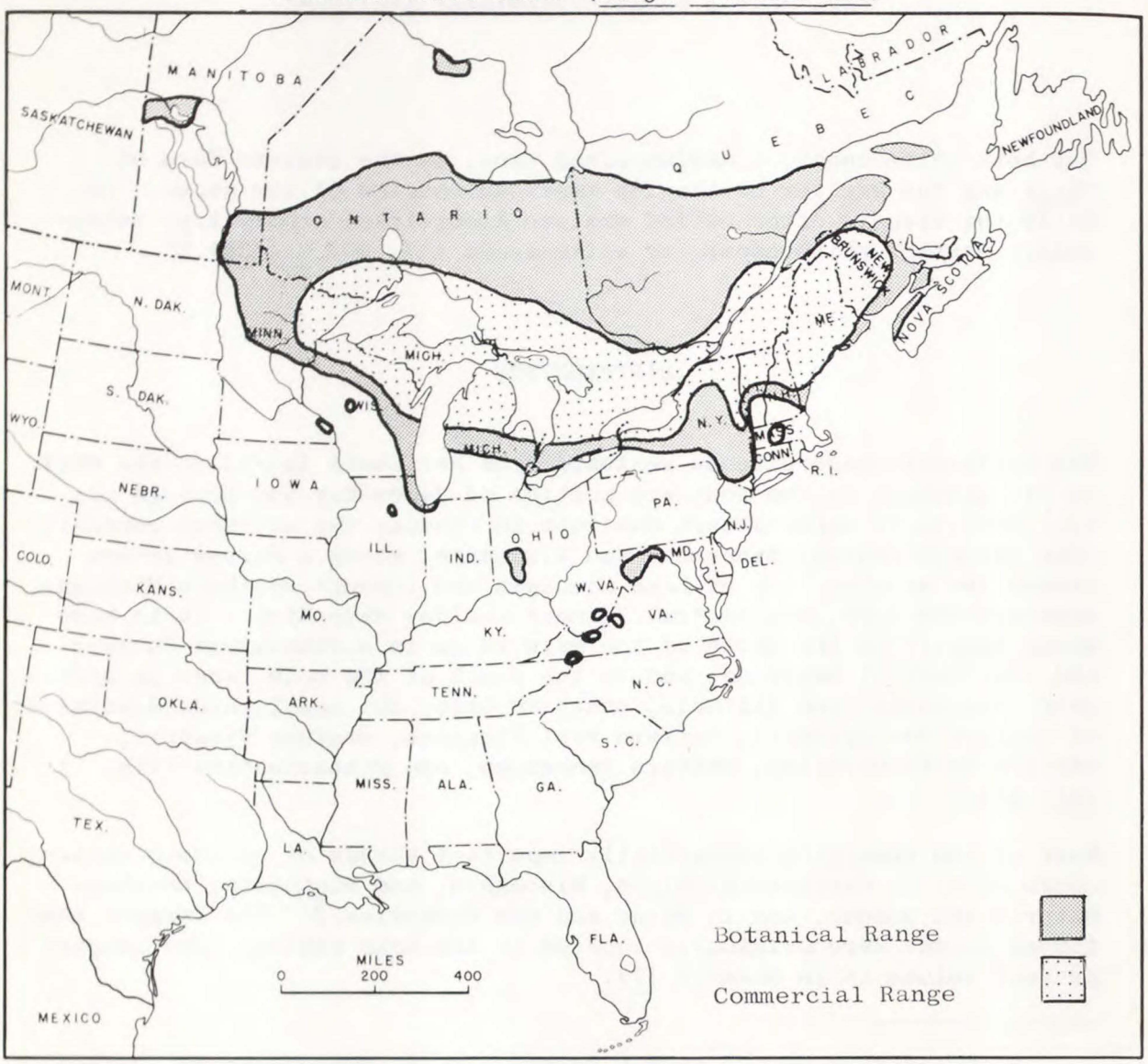

Figure 1.--Botanical and commercial range of northern white-cedar.

HABITAT CONDITIONS

Climatic Factors

The climate in which northern white-cedar grows is relatively humid. Annual precipitation in the botanical range varies from slightly less than 20 inches in the northern and western limits to about 55 inches in the Appalachian region. A large proportion occurs as snowfall, ranging from 40 to 140 inches annually. Precipitation is generally well distributed throughout the year, with one-third to one-half of the yearly total occurring during the warm season (18).

The temperatures are relatively cool during a moderately short growing season. The northern limit of northern white-cedar extends to the tundra-boreal forest transition zone in Canada. The southern portion of the botanical range occurs in an area having a mean annual temperature of less than 50° F. in the Lake States and up to 60° in the Appalachians. The average July temperature seldom, if ever, exceeds 75°, with an average of 70° being more common except in the isolated portions of the range in the Midwest. The length of the frost-free period varies from a maximum of 200 days in the United States to probably less than 30 days in the northern limit of the Canadian range.

Within the commercial range where the northern white-cedar type is most common, climatic variations for three areas are as follows (33):

	Upper Peninsula of Michigan	Northern Wisconsin	Maine
Mean July temperature--degrees F.	60- 66	66- 70	62- 70
Mean Jan. temperature--degrees F.	10- 16	10- 22	10- 24
Frost-free period--days	80-140	90-170	100-180
Average annual precipitation--inches	28- 32	28- 32	34- 46

Edaphic and Physiographic Factors

Northern white-cedar grows both in swamps and on uplands but does not develop well on extremely wet or extremely dry sites. Most of the commercial stands are found in the swamplands, characteristic results of glacial action (30). In swamps, the site quality for white-cedar improves as the depth of peat decreases (30, 39) and as the internal drainage improves (25, 26, 30, 36).

The character of the organic material, however, is more important than the depth (8). "Good" peat is made up of remains of woody plants or sedges that are partly to well decomposed. "Poor" peat is generally made up of remains of plants such as sphagnum mosses, reeds, and rushes that are mostly or entirely undecomposed. (39)

On upland sites, moist well-drained fields, and shallow rocky pastures, where soils vary from calcareous clay to gravel, the species is found in scattered picturesque clumps or dense pure stands (9, 11). Growth is about three times faster on old-field sites than on poorly drained swamps, and the majority of old-field white-cedars have good form (11).

The species prefers soils of calcareous origin--generally it does best on neutral or alkaline soil--but it is also found throughout acid swamps (23). It is more likely to grow straight on good sites. Pistol-butts and bowed-butts, due to poor anchorage and snow pressure, are common in swamp-grown cedar (11, 23, 39, 43).

The fresh-fallen leaf litter under northern white-cedar stands has a nutrient element content of about 2.16 percent calcium, 0.15 percent magnesium, 0.25 percent potassium, 0.04 percent phosphorus, and 0.60 percent nitrogen, based on the amount of the element as a percentage of the dry weight. The acidity of the leaves has a pH range of 4.0 to 4.9 (22).

Biotic Factors

Although northern white-cedar is the major species in only one forest cover type (the northern white-cedar type), it is an associate species in eight other forest types of the northern forest region, in two of the boreal forest, and in two types common to both regions. These types include (29):

SAF type no.	Forest cover type	Region
9	White spruce-balsam fir-aspen	Boreal
13	Black spruce-tamarack	"
5	Balsam fir	Boreal and Northern
12	Black spruce	" " "
21	White pine	Northern
24	Hemlock-yellow birch	"
30	Red spruce-yellow birch	"
33	Red spruce-balsam fir	"
35	Paper birch-red spruce-balsam fir	"
36	White spruce-balsam fir-paper birch	"
38	Tamarack	"
39	Black ash-American elm-red maple	"

The pure northern white-cedar type occurs in the Lake States on seepage areas and occasionally on limestone uplands. It is commonly found in other cover types on poorly drained flats in the northeastern United States and is rare in Nova Scotia. The pure white-cedar type is usually considered to be a climax association (fig. 2).

Common tree associates on the wetter soils include balsam fir (Abies balsamea), black spruce (Picea mariana), white spruce (P. glauca), tamarack (Larix laricina), black ash (Fraxinus nigra), and red maple (Acer rubrum) and, on the better drained and upland soils, quaking aspen (Populus tremuloides), bigtooth aspen (P. grandidentata), balsam poplar (P. balsamifera), red spruce (Picea rubens), eastern white pine (Pinus strobus), eastern hemlock (Tsuga canadensis), yellow birch (Betula alleghaniensis), paper birch (B. papyrifera), American elm (Ulmus americana), sugar maple (Acer saccharum), basswood (Tilia americana), and northern red oak (Quercus rubra). In mixture with these associates, northern white-cedar is part of a quasi-climax or a transitional type (29).

Common shrubs associated with the northern white-cedar type include the gray dogwood (Cornus racemosa), redosier dogwood (C. stolonifera), willows (Salix spp.), speckled alder (Alnus rugosa), American mountain ash (Sorbus americana), common chokecherry (Prunus virginiana), American elder (Sambucus canadensis), gooseberries (Ribes spp.), American cranberrybush (Viburnum trilobum), beaked hazelnut (Corylus cornuta), mountain maple (Acer spicatum), Canada yew (Taxus canadensis), honeysuckles (Lonicera spp.), and western thimbleberry (Rubus parviflorus).

Figure 2.--Virgin stand of northern white-cedar, Upper Peninsula of Michigan.

Common herb associates include Canada beadruby (Maianthemum canadense), bunchberry dogwood (Cornus canadensis), sedges (Carex spp.), field horsetail (Equisetum arvense), bedstraw (Galium spp.), buttercup (Ranunculus spp.), skunkcabbage (Symplocarpus foetidus), common jackinthepulpit (Arisaema atrorubeus), spotted snapweed (Impatiens biflora), virginia springbeauty (Claytonia virginica), asters (Aster spp.), purple meadowrue (Thalictrum dasycarpum), snow trillium (Trillium grandiflorum), violets (Viola spp.), bloodroot (Sanguinaria canadensis), tall nettle (Urtica procera), woodnettle (Laportea canadensis), American maidenhair fern (Adiantum pedatum), wild sarsaparilla (Aralia nudicaulis), rosy twistedstalk (Streptopus roseus), feather solomonplume (Smilacina racemosa), solomonseal (Polygonatum pubescens), yellow beadlily (Clintonia borealis), partridgeberry (Mitchella repens), ladyslipper (Cypripedium acaule), common pitcherplant (Sarracenia purpurea), Alaska goldthread (Coptis trifolia), American starflower (Trientalis borealis), and Labradortea (Ledum groenlandicum) (23, 39).[4/] Clubmoss (Lycopodium spp.) is usually present in all stands (41) as are hypnum mosses (Hypnum spp.).

LIFE HISTORY

Seeding Habits

Flowering and Fruiting

Northern white-cedar usually flowers in late April or the early part of May (24, 34). The staminate flowers occur in yellow clusters and the ovulate flowers, borne on the tips of separate branches on the same tree, occur in small reddish clusters. In northern Michigan[5/] cone formation begins about June 22, cone growth is completed about August 18, and opening begins about October 5, varying from mid-September to late October. The interval between cone ripening and cone opening is short, varying only from 7 to 10 days. (34)

4/ Zillgitt, W. M. 1950. Silvical requirements and species behavior--problem analysis. Lake States Forest Expt. Sta. unpublished report.

5/ Unpublished data, Lake States Forest Experiment Station.

Seed Production

The tree bears good seed crops about every 3 to 5 years, with light to medium crops in the intervening years (26, 34). The commercially cleaned seeds average 346,000 per pound (34). Seed production has been reported on stems as young as 6 years of age. The tree begins to produce seed abundantly at 20 years, but commercial seed production starts at about 30 years and is best after 75 years (23, 26, 34). Nelson (23) reports that it is not uncommon for an average size tree with a fairly full crown to produce ¼ bushel of cones. Each cone is made up of 3 to 10 pairs of flexible scales of which only the middle 2 or 3 pairs are ordinarily fertile. Each fertile scale usually bears 2 winged seeds (34).

Isolated trees, especially those on upland sites, produce seed more prolifically than the trees on swamp sites.

Seed Dissemination

Natural seed dissemination usually starts in September, although it sometimes begins as early as August. Most of the seed is dispersed by November, but some seedfall occurs throughout the winter months. Practically all of the seed is wind-disseminated. Since the tree is usually not very tall, the effective seeding range is estimated to be from 150 to 200 feet, except during unusually high winds (23, 39). Red squirrels (Tamiasciurus hudsonicus) frequently clip small branches bearing cones and the percent dispersed or eaten may have an effect on the distribution (23).

Vegetative Reproduction

Layering, principally that of branches, and the formation of vertical stems from windthrown trees are common means of vegetative reproduction in swamps (11, 26). Nelson (23) found branch layering to account for over 60 percent of the stems of cedar reproduction in northern Michigan swamps, which generally agrees with the results from studies of swamp reproduction in Maine. Ordinarily, however, most of the reproduction on the upland sites is from seed (11).

Seedlings have the ability to reproduce by layering when approximately 5 years old (23). Layering is most common in younger stands and on areas where windthrown trees are prevalent.

Rodent and snowshoe hare browsing, deer browsing, root rot, and failure of adventitious roots to develop are common causes of mortality in layering. Northern white-cedar rarely sprouts from roots or stumps or develops root suckers, although this type of reproduction has been reported (23).

Northern white-cedar can be propagated vegetatively by cuttings with a high degree of success. This method is commonly used by horticulturists to grow the more than 50 different varieties used for hedges and ornamental plantings. Occasionally clipped twigs that have rooted can be found in natural stands (23).

Seedling to Maturity

Establishment

Northern white-cedar seedlings develop most commonly on rotten wood, decayed litter, peat, and moss. They are also aggressive on burns on both upland and swamp soils. Reproduction comes in best on skid roads where the moss has been packed down and stays moist throughout the summer (23, 26, 39). Slash and thick moss layers tend to retard germination.

Germination (epigeous) normally begins in May or June of the year following seed dissemination. As a rule the seed shows only slight internal dormancy although occasional lots may be markedly dormant. The seed deteriorates rapidly when stored at temperatures higher than 40° F. or when exposed to moisture. Average germination is about 45 to 50 percent. The seedlings do best on neutral or slightly acid soil and will grow on slightly alkaline soil (26).

Seedlings are distinguishable from vegetative reproduction by the presence of juvenile leaves along the main stem. Such leaves are oppositely arranged and generally tend to form four vertical rows on the young stem in comparison to the whorled arrangement on adult foliage. Adult foliage is often established during the first year of growth, but in some cases juvenile foliage exists on the lower branches up to 10 years of age (23).

During the first several years the seedling tends to develop a tap root. Later, this tap root system is replaced by a fibrous root system (23). Northern white-cedar is the only northeastern conifer that does not have mycorrhizal fungi associated with its roots (23).

Mortality of seedlings, excluding that caused by browsing, varies with climatic conditions, type of seedbed, and competition. One study showed that desiccation caused over one-third of the mortality (23). In many instances, seeds germinated on media, such as heavy moss and the tops of stumps and logs during the wet spring season, which dried out during the summer. In this same study other causes of loss in order of importance were late spring frosts, root rot, mechanical effect of litter and duff, poorly developed root system, and competition from grasses. The seedlings are resistant to infection by damping-off fungi (5). Rodent and snowshoe hare browsing caused slightly more mortality than desiccation according to one study (23). On some sites, where plantations are subjected to flooding or a high water table in the spring, frost heaving frequently causes considerable mortality (5).

Most of the silvicultural methods used in swamp cuttings do not give consistently favorable results, largely because of site differences and variation in species composition. Experimental studies of cutting methods designed to favor regeneration of northern white-cedar are not yet far enough advanced to provide an adequate basis for making specific recommendations.

A survey of cutover swamps in the Upper Peninsula of Michigan, varying in time since cutting from 5 to 15 years, showed that cedar regeneration was most abundant in partially cut stands regardless of site conditions. Although northern white-cedar restocking was generally satisfactory, the proportion was usually less than in the original stand because of hardwood invasion and an increase in balsam fir (42). On most sites initial reproduction is greater where a residual stand of 300 to 700 trees per acre has been left (23, 42). Clear cutting in strips about 75 feet wide and up to ¼ mile long with uncut strips in between has given satisfactory results in some swamp cuttings (40).

Distribution of slash from these cuttings has a pronounced effect on cedar reproduction. Lopping and scattering usually results in better stocking and distribution of cedar and other coniferous reproduction than occurs on areas that are free of slash or those covered with heavy slash (23, 39, 42).

Early Growth

In northern Michigan, records over a 9-year period show that leaf buds usually begin to burst open on May 7; seasonal height growth begins on May 21 (varying from May 2 to June 10), and is completed by about August 30; radial growth begins May 24 and terminates about September 16; and winter buds form about September 19, or about the same time as radial growth ceases.[5/] During one year in New Brunswick terminal

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5/ Unpublished data, Lake States Forest Experiment Station.

shoot growth began about May 15, reached a peak about June 14, and ceased on September 29. Lateral and side shoots made their greatest growth in early June and decreased steadily thereafter. Radial growth also began about May 15, reached its peak about June 25, was largely completed by September 15, but did not cease until October 3. It showed no correlation with temperature, hours of sunshine per day, or weekly precipitation (28).

In fully stocked stands on the better sites in the Lake States (site index 75 - height in feet at age of 160 years) the average diameter and total height of trees 0.1 inch and larger in 40-year-old stands is 3.6 inches and 28 feet compared with 1.4 inches and 8 feet on the poorer sites (site index 25). The 30-year-old stands average 2.3 inches and 19 feet on site index 75 compared with 0.8 inch and 6 feet on site index 25.

Growth and Yield

Northern white-cedar is a tree of medium size, commonly 40 to 50 feet tall and reaching 2 to 3 feet in diameter. Infrequently the tree attains a maximum size of 80 feet tall and 6 feet in diameter (17). It is generally considered to be slow growing. On average swamp sites in the Lake States, it takes from 80 to 100 years to grow a tree to a 6-inch diameter. To produce a post on the typical swamp sites requires about 60 to 80 years, a tie 150 to 175 years, and a 20-foot pole about 200 years (13). On upland sites the growth rate is more rapid and only 110 to 160 years are required to grow a 20-foot pole. Northern white-cedar generally grows more slowly than its associated species and is longer lived, reaching ages of 400 years or more in the swamp or lowland types (17, 38, 39).

Fully stocked stands of northern white-cedar in the Lake States reach average heights, diameters, and volumes per acre at various ages as shown in Table 1 on opposite page (13).

Reaction to Competition

Northern white-cedar is considered a tolerant tree. It has been placed both in the highest and in the next highest of five classes of tolerance (4, 44). A recent classification gives northern white-cedar a numerical rating of 5.0 in a scale which ranges from 0.7 for the aspens to 10.0 for eastern hemlock (15).

On swamp sites northern white-cedar is generally shorter than its associated species because of its slow rate of growth and suppression by

Table 1.--Growth and yield of northern white-cedar (13)

Age (years)	Poor site - site index 25				Good site - site index 75			
	Height 1/	D.b.h. 1/	Volume		Height 1/	D.b.h. 1/	Volume	
			Scribner 2/	Cubic volume 1/			Scribner 2/	Cubic volume 1/
	Feet	Inches	Bd.ft.	Cu.ft.	Feet	Inches	Bd.ft.	Cu.ft.
40	8	1.4	--	680	28	3.6	360	2,440
80	15	3.3	100	1,620	54	8.7	11,070	4,200
120	20	4.6	1,040	2,040	67	12.4	20,310	5,040
160	22	5.3	1,780	2,225	73	14.5	24,370	5,425

1/ Trees 0.1 inch and larger.
2/ Trees 7.0 inches and larger to a 6-inch top.

its associates. It can withstand extreme suppression for several years without appreciable ill effects, and it responds well to release at nearly all ages (26, 39). One 45-year-old stand with trees from 1 to 7 inches in diameter in a swamp having good drainage increased from a residual basal area of 69 square feet to 154 square feet in 8 years following thinning. The untreated stand increased from 161 to 172 square feet during the same period, with mortality reducing the number of stems by slightly over 50 percent. A similar thinning on a poorly drained swamp showed no beneficial effect (25).

Limiting Factors

Moisture is a critical factor in the occurrence of northern white-cedar in its typical swamp condition. A high water table, slow-moving ground water, or stagnant ground water restrict aeration, tend to reduce the rate of growth, and in some cases kill the entire stand (5, 23, 25, 26, 36, 39). Draining of swamps has been shown to have a very favorable effect upon growth (8). Moisture conditions and type of soil frequently limit the species association as well as growth (30, 39).

Northern white-cedar is a relatively shallow-rooted tree. It is subject to windthrow and uprooting, particularly in stands that have been partially cut. Because of their shallow position the roots are easily exposed, trampled by animals, and subjected to drying from fluctuating

water tables (5, 11).[6/] Because it has dense foliage the tree often suffers from snow breakage and bending (8).

This species is also susceptible to damage by fire. The shaggy bark is very thin and has a high oil content. The shallow roots, often covered only by thick layers of moss, frequently are damaged (5, 8).

Northern white-cedar seldom is attacked by insects of any economic importance (8, 11). Most of the pests attack only dead trees or ornamentals of this species. On forest trees the black carpenter ant (Camponotus herculeanus pennsylvanicus) is probably the most serious insect pest; it frequently attacks the dead heartwood of living trees, particularly those that are partially decayed (10, 39). Infestations of the arborvitae leaf miner (Argyresthia thuiella) sometimes occur in the forest without causing serious injury (10). However, trees growing on poor sites such as dry pastures may die following severe feeding damage.

Immature stands of northern white-cedar are relatively free of disease. Fruiting bodies of heart-rotting fungi seldom appear on living trees, the commonest outward sign of rot being the presence of woodpecker holes (5). White stringy butt rot (Poria subacida) and Polyporus balsameus and P. schweinitzii, both causing a brown cubical rot, are common on trees on swamp knolls or in the drier portions of the swamp. Some authors note that Fomes pini, causing a red ring rot of conifers, is common in cedar but this has been questioned (5). The shoestring fungus (Armillaria mellea) is reported to attack all species in the Lake States but the extent of damage to white-cedar is apparently negligible (3, 5). Occasionally seedlings are attacked by juniper blight caused by Phomopsis juniperovora and cedar leaf blight caused by Keithia thujina, but the damage is rarely of serious consequence.[7/]

Northern white-cedar, by a palatability and nutritional rating, is one of the most important sources of winter browse for white-tailed deer (Odocoileus virginianus) (1). In the northern half of Wisconsin a survey of deer damage to forest reproduction showed that only 3 out of every 10 trees remained undamaged (32). Graham (14) reported that, in the western portion of northern Michigan on recently cut areas, cedar under 10 years of age was difficult to find because of the heavy browsing. A clipping study in the Lake States showed that northern white-cedar under 7 feet tall can produce well and continue to grow when something under 15 to 20 percent of the foliage is removed. Heavier clipping retarded the growth and eventually killed the small trees. Larger trees can be browsed heavily below the 7-foot level without injury (2). It has been estimated that the average deer requires 4½

6/ Zillgitt: See footnote 4, page 6.

7/ Personal communication from R. L. Anderson of the Lake States Forest Experiment Station.

pounds of cedar browse a day to maintain good strength. This amount is equivalent to the available browse below 7 feet on a tree 3 inches in diameter and of average height (37).

In some regions, snowshoe hare (Lepus americanus) browsing does almost as much damage as deer browsing (32). On Isle Royale, moose (Alces alces americana) were found to browse white-cedar, although it was not a preferred food (19). Porcupines (Erithizon dorsatum) frequently injure trees by partially or completely girdling the stem and branches; this may result in death or a lowering of the growth and quality of the timber (31). Red-backed voles (Clethrionomys gapperi) have been found to make small cuttings of terminal twigs and laterals of smaller seedlings (16). Squirrels, in addition to clipping the cone-bearing branches, frequently eat the flower buds (11).

SPECIAL FEATURES

Northern white-cedar is used principally for poles, ties, posts, mine timber and lagging, shingles, and lumber, and for ornamental planting, wreaths, and decorations. Considerable amounts of lumber are used in the construction of tanks, boats, woodenware, millwork, novelties, and boxes and crates. A limited amount of cedar-leaf oil, distilled from the leaves, is used in medicine (6, 8, 9, 20, 39).

The wood is very light in weight, of low shrinkage, and comparatively free from warping, and is soft, brittle, and weak. It splits readily, has a characteristic aromatic odor, and has a fine uniform texture. It is easily worked and holds paint well. The sapwood, usually less than an inch in width, is nearly white, while the heartwood is light brown with a reddish tinge. The heartwood is resistant to decay, making it especially desirable for service in contact with the ground (35).

The use of northern white-cedar for game planting is becoming important (34). It was formerly planted in Minnesota for prairie shelterbelts, but it does not withstand drought very satisfactorily (12). It has frequently been planted for nursery hedges in the Lake States.

RACES, HYBRIDS, AND OTHER GENETIC FEATURES

At least 50 varieties of northern white-cedar, varying in foliage color and growth habit, are cultivated for use as ornamental plantings (38). Although no races or varieties have been reported in commercial forest areas, it is probable in view of the species' wide range that some geographic races have developed. Neither natural nor artificial hybrids

involving northern white-cedar have been reported. Each vegetative cell of ordinary wild white-cedars contains 11 pairs (22) of chromosomes (27).

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Station Paper 50 - Sugar maple
Station Paper 52 - Tamarack
Station Paper 54 - American elm
Station Paper 55 - White spruce
Station Paper 59 - Slippery elm
Station Paper 61 - Jack pine
Station Paper 62 - American basswood
Station Paper 63 - Bigtooth aspen
Station Paper 65 - Balsam poplar
Station Paper 66 - Black maple

SOME RECENT STATION PAPERS

Chemical Control of Brush and Trees in the Lake States.
Paul O. Rudolf and Richard F. Watt.
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